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(54) **AREA SENSOR AND EXTERNAL STORAGE DEVICE**

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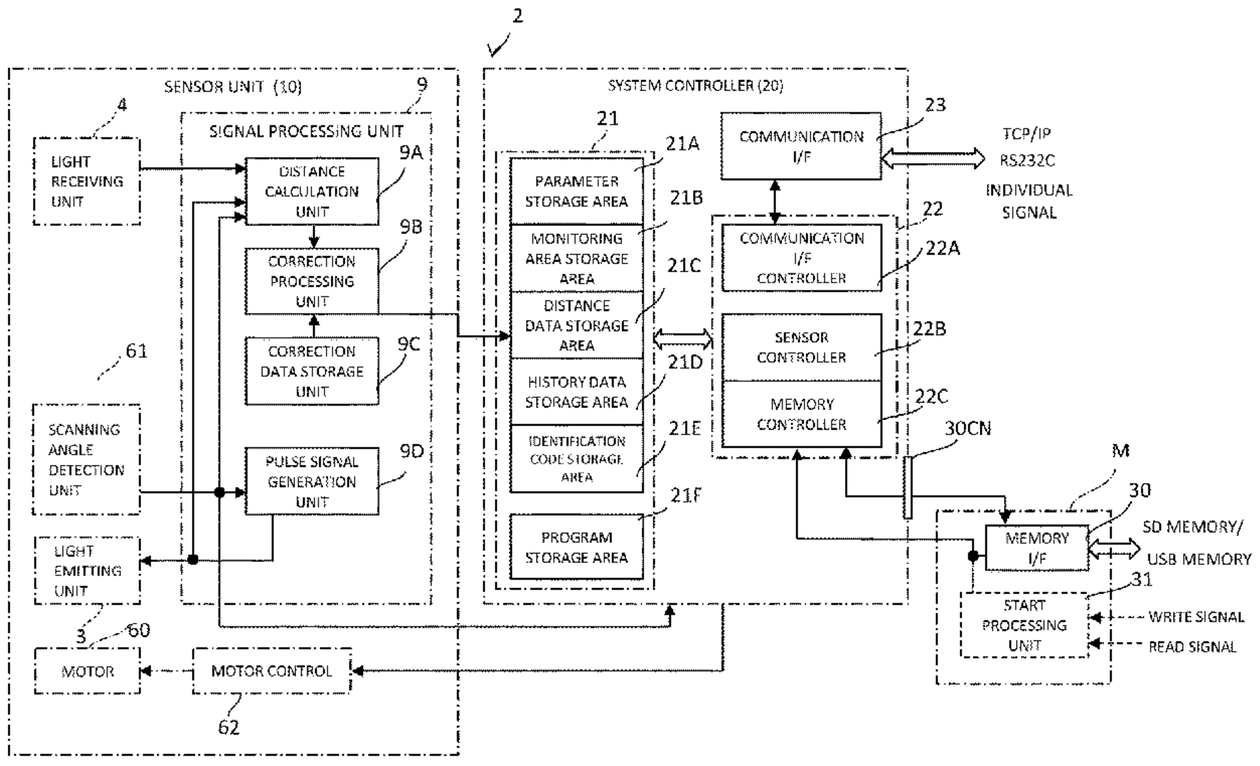
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(57) **ABSTRACT**

An area sensor includes: a sensor unit that emits measurement light with which a monitoring area is scanned, and detects reflected light of the measurement light; and a system controller that controls the sensor unit to output sensor information to an external device, the sensor information including object information in the monitoring area obtained based on an output signal from the sensor unit, the system controller including: a memory interface to which a portable external storage device is connectable, a sensor controller that controls the sensor unit, and a memory controller that accesses the external storage device; and a start processing unit which operates the memory controller in priority to the system controller, when the external storage device is connected to the memory interface.

16 Claims, 7 Drawing Sheets



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G01S 17/93	(2020.01)

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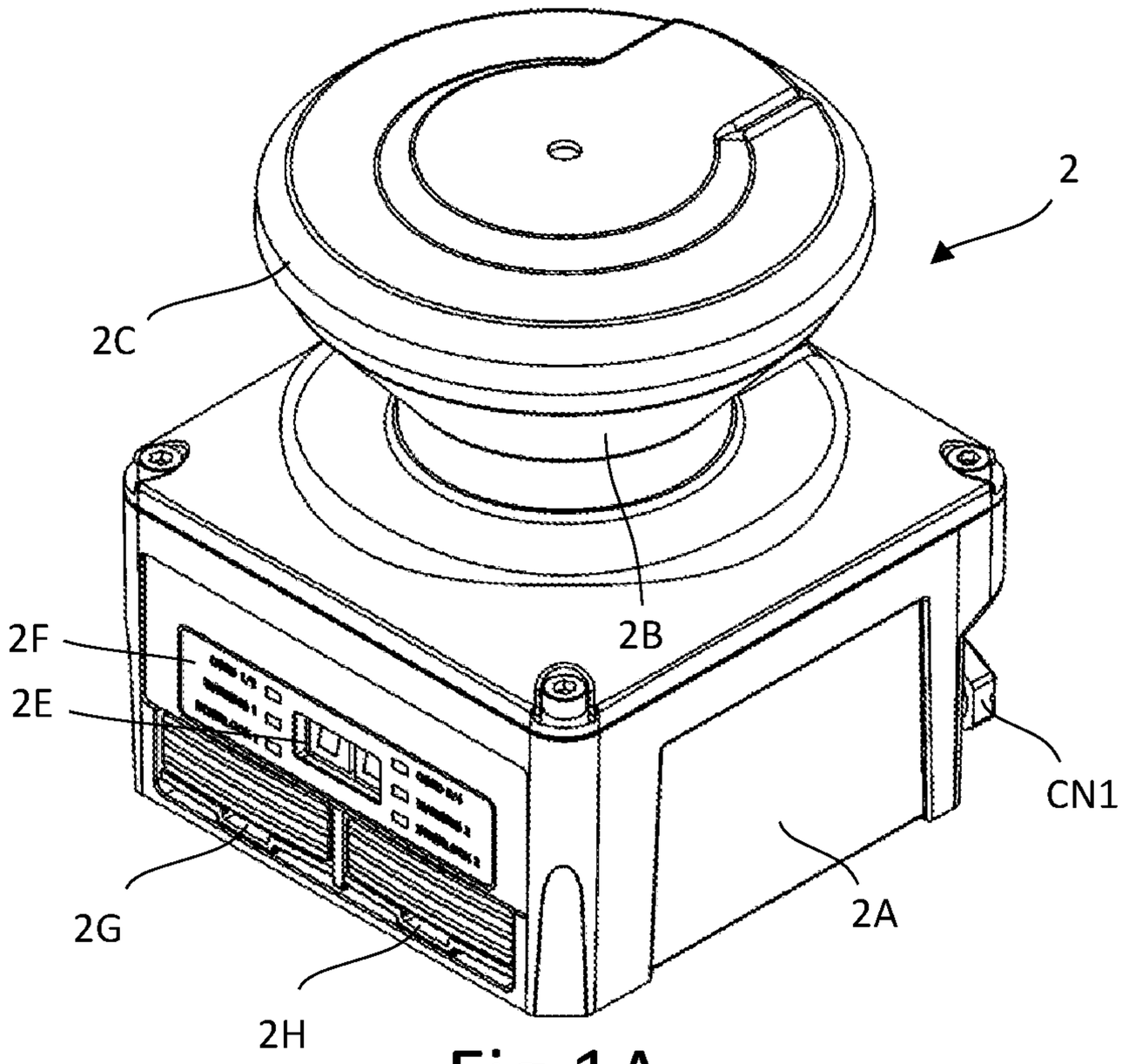

2
2C
2B
2F
2E
CN1
2G
2A
2H

Fig.1A

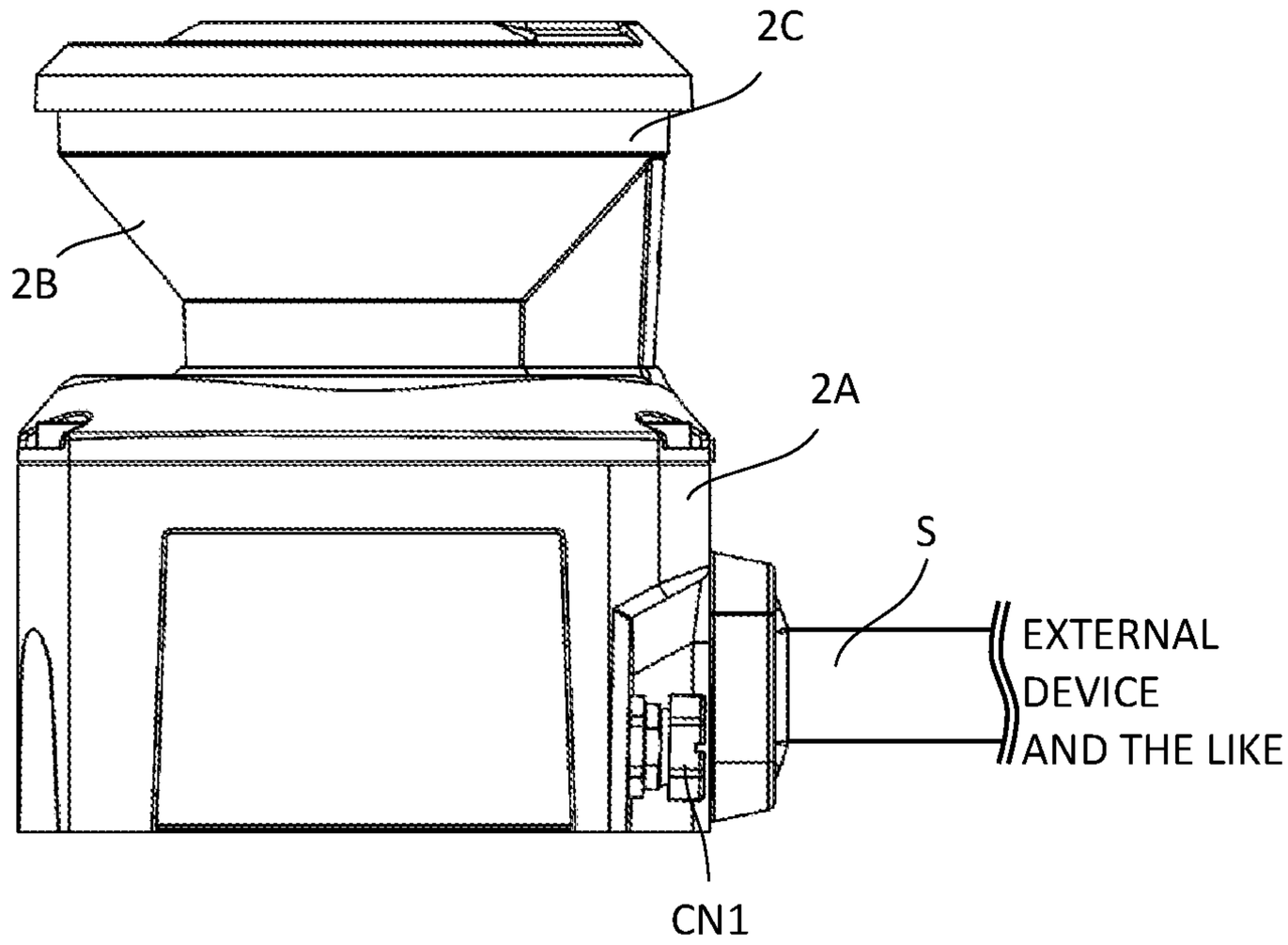

2C
2B
2A
S
EXTERNAL
DEVICE
AND THE LIKE
CN1

Fig.1B

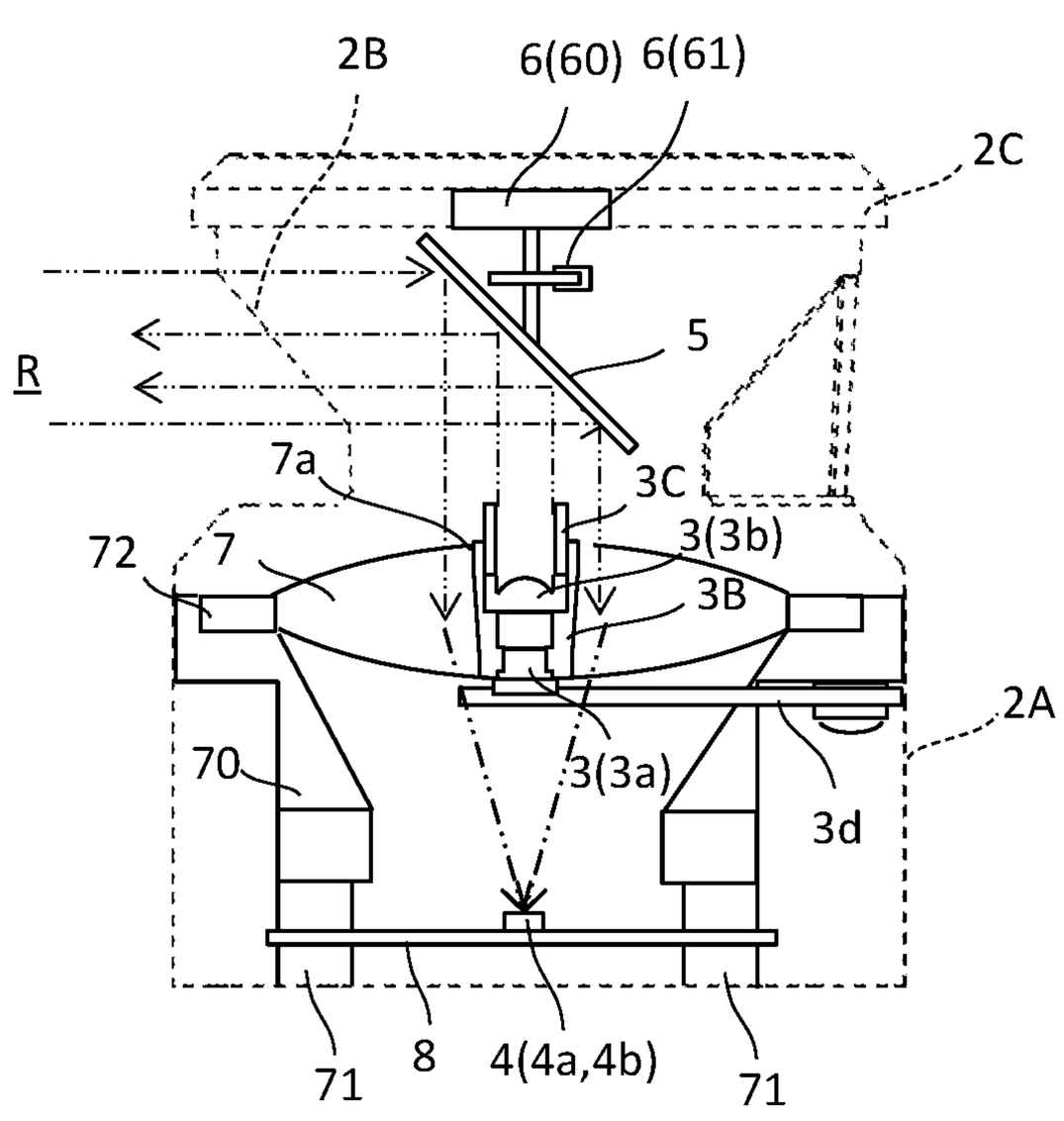


Fig.2

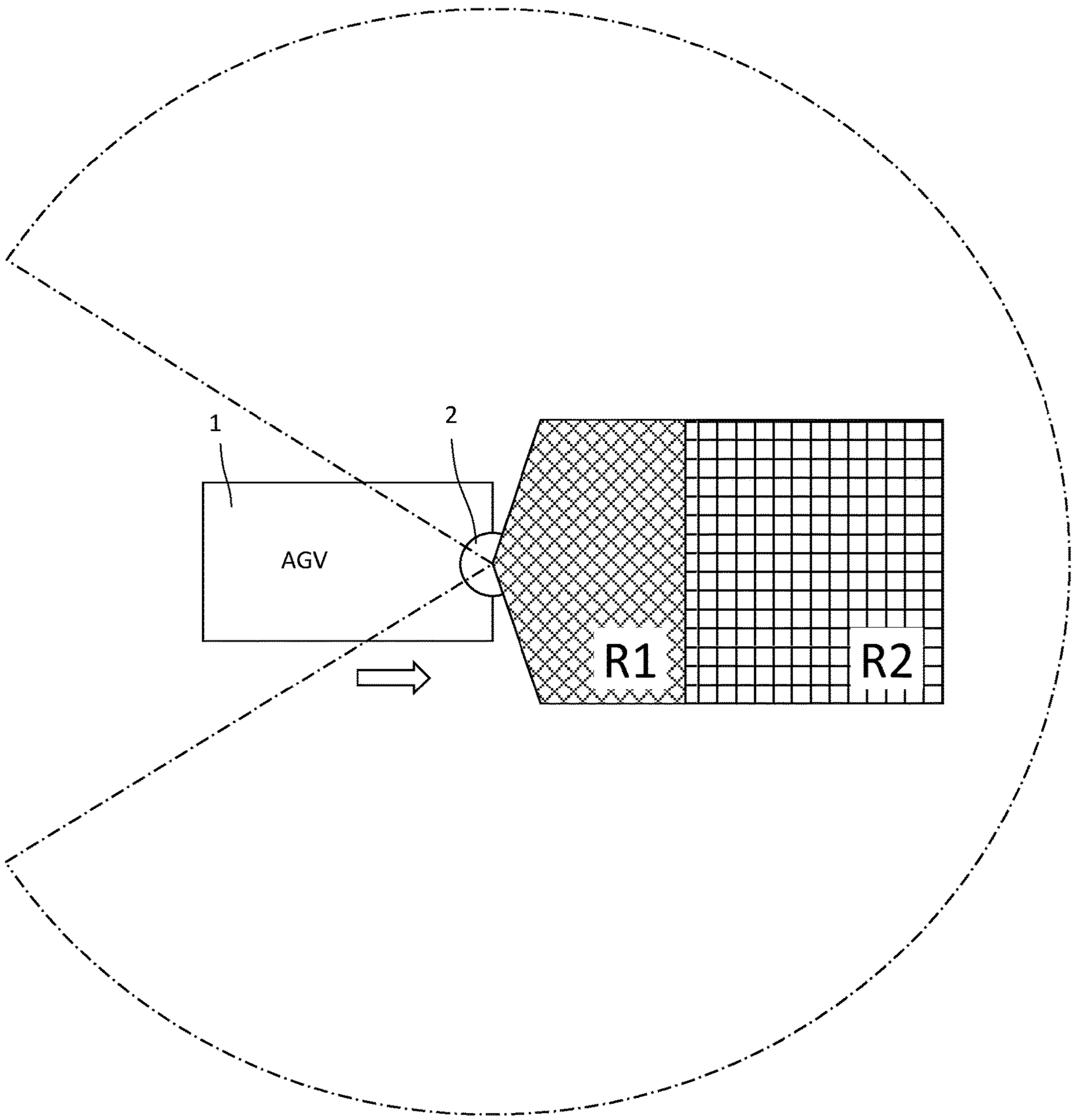


Fig.3

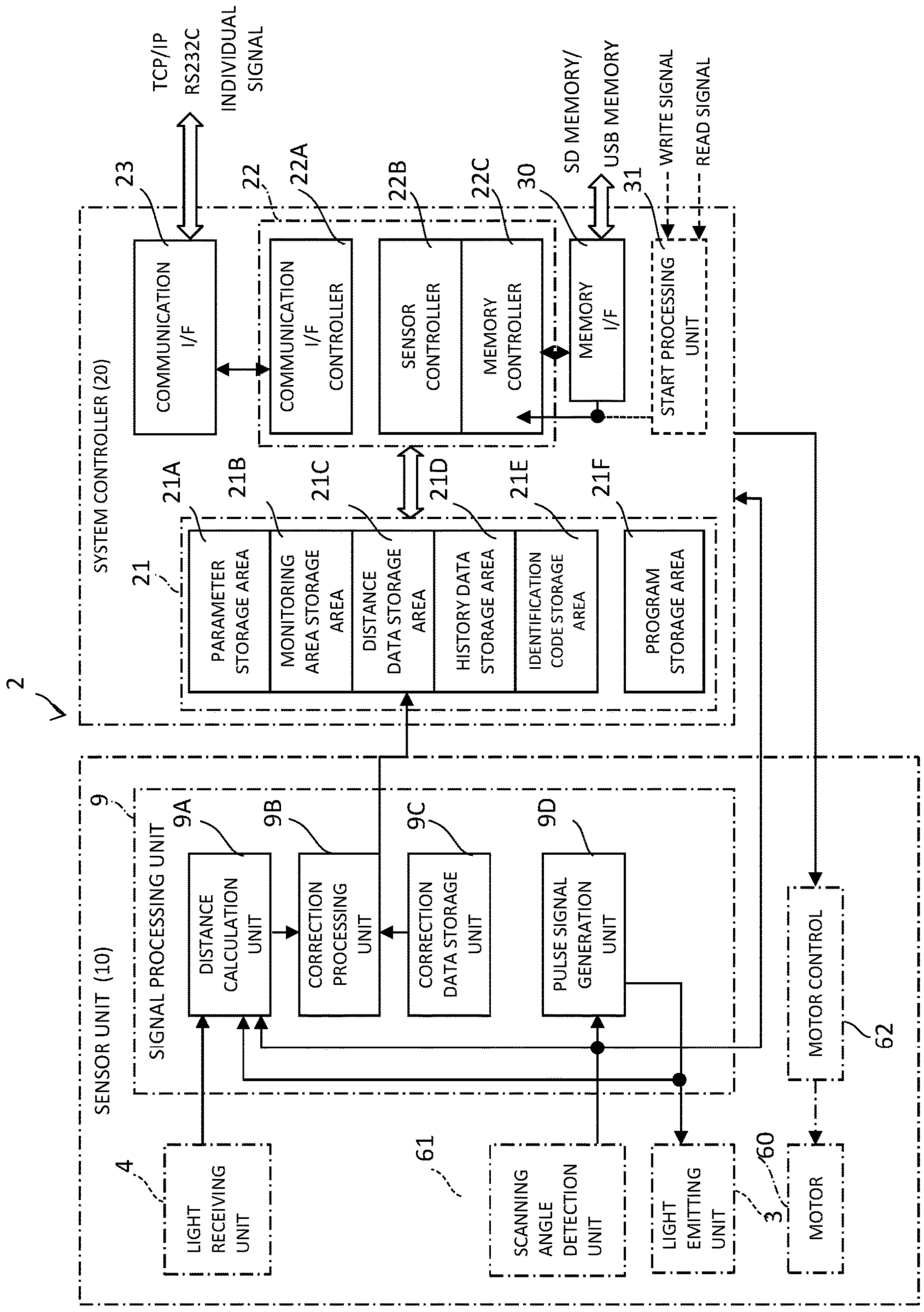

SENSOR UNIT (10)
SIGNAL PROCESSING UNIT
9
9A
9B
9C
9D
DISTANCE CALCULATION UNIT
CORRECTION PROCESSING UNIT
CORRECTION DATA STORAGE UNIT
PULSE SIGNAL GENERATION UNIT
LIGHT RECEIVING UNIT
4
SCANNING ANGLE DETECTION UNIT
61
LIGHT EMITTING UNIT
3
MOTOR
60
MOTOR CONTROL
62
SYSTEM CONTROLLER (20)
2
21
PARAMETER STORAGE AREA
21A
MONITORING AREA STORAGE AREA
21B
DISTANCE DATA STORAGE AREA
21C
HISTORY DATA STORAGE AREA
21D
IDENTIFICATION CODE STORAGE AREA
21E
PROGRAM STORAGE AREA
21F
COMMUNICATION I/F
23
COMMUNICATION I/F CONTROLLER
22
22A
SENSOR CONTROLLER
22B
MEMORY CONTROLLER
22C
MEMORY I/F
30
START PROCESSING UNIT
31
TCP/IP
RS232C
INDIVIDUAL SIGNAL
SD MEMORY/
USB MEMORY
WRITE SIGNAL
READ SIGNAL

Fig.4

COMMAND CODE	CONDITION CODE	SD MEMORY ADDRESS	AREA SENSOR ADDRESS	IDENTIFICATION CODE
WRITE	MONITORING AREA	*****	*****	1,2,3,4,5
WRITE	PARAMETER	*****	*****	1,2,3,4,5
WRITE	UPDATE PROGRAM	*****	*****	1,2,3,4,5
READ	MONITORING AREA	*****	*****	6
READ	HISTORY DATA	*****	*****	6
WRITE	UPDATE PROGRAM	*****	*****	7,8,9
...	...	...	...	...

Fig.5

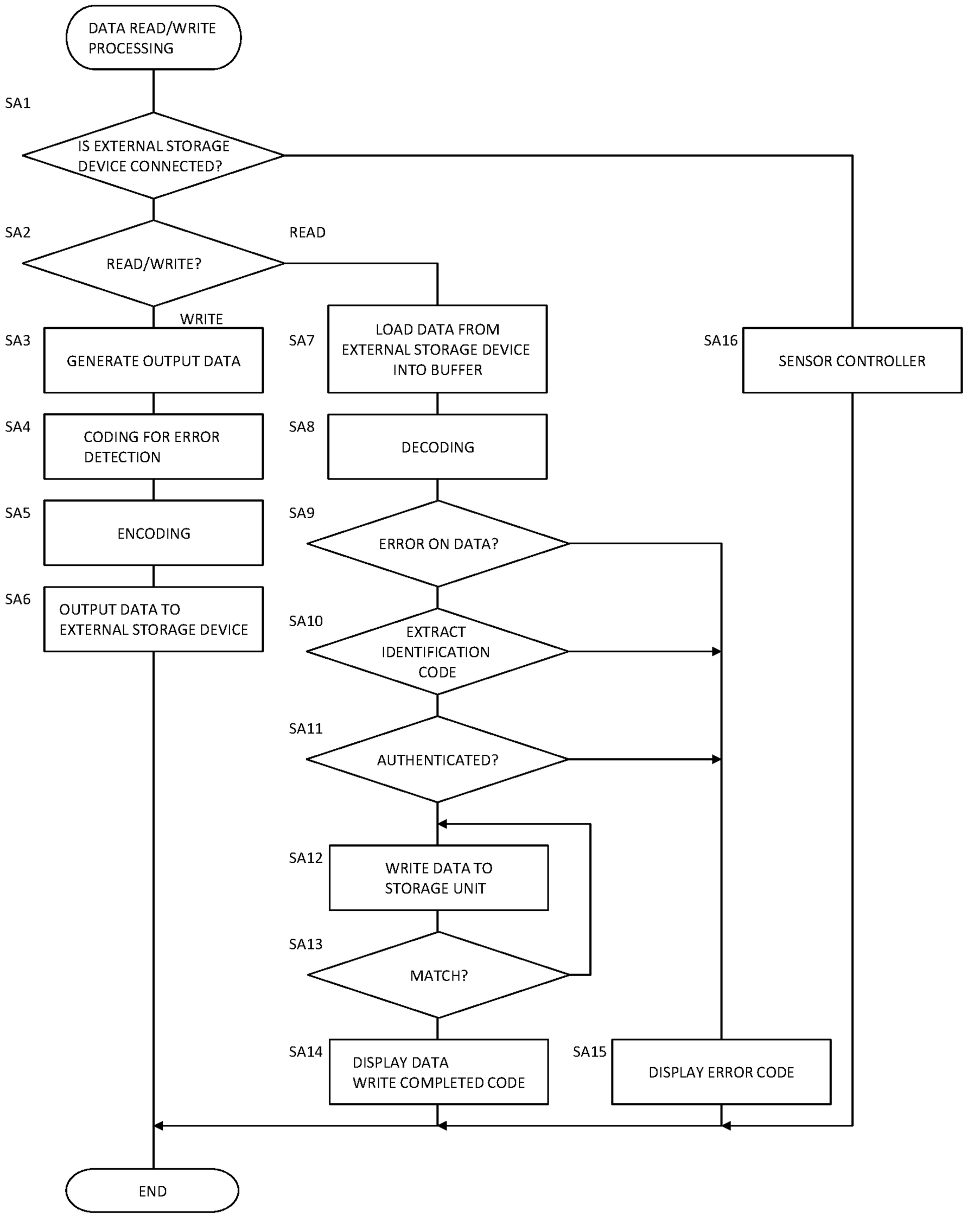

DATA READ/WRITE PROCESSING
SA1
IS EXTERNAL STORAGE DEVICE CONNECTED?
SA2
READ/WRITE?
READ
WRITE
SA3
GENERATE OUTPUT DATA
SA4
CODING FOR ERROR DETECTION
SA5
ENCODING
SA6
OUTPUT DATA TO EXTERNAL STORAGE DEVICE
SA7
LOAD DATA FROM EXTERNAL STORAGE DEVICE INTO BUFFER
SA8
DECODING
SA9
ERROR ON DATA?
SA10
EXTRACT IDENTIFICATION CODE
SA11
AUTHENTICATED?
SA12
WRITE DATA TO STORAGE UNIT
SA13
MATCH?
SA14
DISPLAY DATA WRITE COMPLETED CODE
SA15
DISPLAY ERROR CODE
SA16
SENSOR CONTROLLER
END

Fig.6

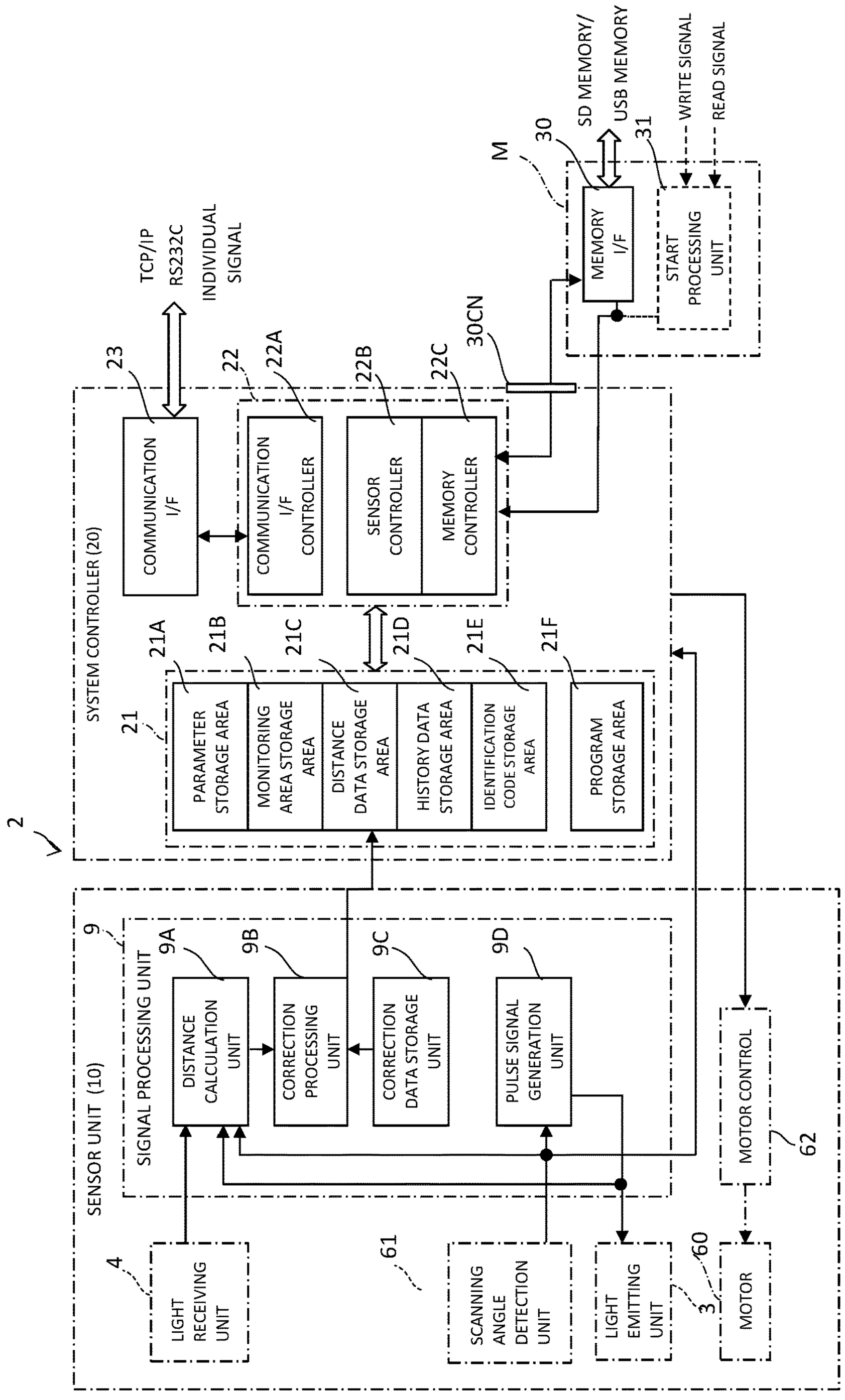

SENSOR UNIT (10)
SYSTEM CONTROLLER (20)
SIGNAL PROCESSING UNIT
9
9A
DISTANCE CALCULATION UNIT
9B
CORRECTION PROCESSING UNIT
9C
CORRECTION DATA STORAGE UNIT
9D
PULSE SIGNAL GENERATION UNIT
21
21A
PARAMETER STORAGE AREA
21B
MONITORING AREA STORAGE AREA
21C
DISTANCE DATA STORAGE AREA
21D
HISTORY DATA STORAGE AREA
21E
IDENTIFICATION CODE STORAGE AREA
21F
PROGRAM STORAGE AREA
22
22A
COMMUNICATION I/F CONTROLLER
22B
SENSOR CONTROLLER
22C
MEMORY CONTROLLER
23
COMMUNICATION I/F
30
30C
MEMORY I/F
31
START PROCESSING UNIT
M
SD MEMORY/ USB MEMORY
WRITE SIGNAL
READ SIGNAL
TCP/IP
RS232C
INDIVIDUAL SIGNAL
2
4
LIGHT RECEIVING UNIT
61
SCANNING ANGLE DETECTION UNIT
LIGHT EMITTING UNIT
3
60
MOTOR
MOTOR CONTROL
62

Fig.7

AREA SENSOR AND EXTERNAL STORAGE DEVICE

FIELD OF THE INVENTION

The present invention relates to an area sensor including: a sensor unit that emits measurement light with which a monitoring area is scanned, and detects reflected light of the measurement light; and a system controller that controls the sensor unit to output sensor information to an external device, the sensor information including object information in the monitoring area obtained based on an output signal from the sensor unit.

DESCRIPTION OF THE RELATED ART

A sensor unit in an area sensor includes a distance measurement device employing Time of Flight (TOF) or amplitude modulation (AM). This sensor unit is controlled by a system controller.

The area sensor is used as various sensors including: a visual sensor for a robot and an automatic guided vehicle; an opening/closing sensor for a self-opening door; a monitoring sensor that detects whether something or someone has entered a monitoring target area; and a safety sensor for safely stopping a dangerous device when something or someone approaching the device is detected.

TOF is a method of calculating a distance between the area sensor and an object in the monitoring area based on a difference Δt in detected time between measurement light, which is a pulsed laser beam output to the monitoring area, and reflected light that is the measurement light reflected on the object. Specifically, a distance D is calculated with the following formula

$$D=\Delta t \cdot C/2,$$

where C represents the speed of light.

AM is a method including modulating an amplitude of the measurement light and calculating the distance between the area sensor and the object in the monitoring area based on a phase difference $\Delta\varphi$ between the measurement light output to the monitoring area and the reflected light that is the measurement light reflected by the object. Specifically, the distance D is calculated with the following formula

$$D=\Delta\varphi \cdot C/(4\pi \cdot f),$$

where C represents the speed of light and f represents a modulation frequency.

Patent document 1 discloses an obstacle detection sensor attached to an automatic guided vehicle. This obstacle detection sensor attached to the automatic guided vehicle includes a distance measurement unit, a detection area registration unit, a used pattern setting unit, and a determination unit.

The distance measurement unit measures a distance to a detection object for each of predetermined angle ranges obtained by radially dividing a peripheral area. The detection area registration unit registers a plurality of patterns of detection areas defined by lines connecting a plurality of boundary points set in the measurement range of the distance measurement unit.

The used pattern setting unit selects and sets a pattern to be used from the patterns of a plurality of detection areas registered in the detection area registration unit, for each traveling section of the automatic guided vehicle. The determination unit outputs information indicating that an obstacle is detected while the automatic guided vehicle is travelling, when a distance to a detected object measured by the distance measurement unit for each predetermined angle range is within a detection area set to the current travelling section.

Patent document 2 discloses a method of acquiring laser scanner setting. In the method, data setting and measurement result of a laser scanner, in a laser measurement system using a laser beam, are remotely acquired.

This method of wirelessly acquiring laser scanner setting is implemented with a laser measurement device provided with a distance measurement unit. The laser measurement device includes a light emitting unit that emits a laser beam and a light receiving unit that receives reflected light of the laser beam. The distance measurement unit measures a distance to a measurement target object based on time difference between a light beam emitting timing and a reflected light receiving timing. The distance measurement unit transmits a measurement signal to a remote control device through wireless communications. The remote control device transmits a control signal to the laser measurement device through wireless communications. Thus, the remote control device acquires a result of the measurement by the laser measurement device, and signal setting of the laser measurement device is controlled.

PRIOR ART DOCUMENTS

Patent Documents

[Patent document 1] Japanese Unexamined Patent Application Publication No. 2002-215238

[Patent document 2] Japanese Unexamined Patent Application Publication No. 2013-96860

SUMMARY OF INVENTION

Problems to be Solved by the Invention

Registration of a detection area, that is, a monitoring area of the obstacle detection sensor described in Patent document 1 requires the following procedures. Specifically, before the registration is performed, dedicated monitoring area setting software is started on a personal computer and a plurality of monitoring areas are generated, and then the obstacle detection sensor and the personal computer are connected to each other through a communication line. Then, data, defining the monitoring area, generated by the personal computer is stored in a memory of the obstacle detection sensor.

This series of procedures including connecting the personal computer to the obstacle detection sensors and then setting the monitoring area for each of the sensors is extremely cumbersome.

A control program for the obstacle detection sensor may be updated or changed in the other like way after the obstacle detection sensor has been shipped. Then, a similar procedure involving a similar problem is required. Specifically, the personal computer needs to be connected to each of the obstacle detection sensors for updating and changing the control program stored in a flash read only memory (ROM) provided in the sensor.

The method of wirelessly acquiring laser scanner setting described in Patent document 2 requires no procedure of connecting the personal computer to each of the obstacle detection sensors but still requires cumbersome procedures. Specifically, a personal computer needs to be brought to an installed environment of the obstacle detection sensor in the

first place, and a communication line needs to be established each time a personal computer is brought to set up, and then the data defining the monitoring area and the update program need to be transmitted.

The present invention is made in view of the above problems, and an object of the present invention is to provide an area sensor and an external storage device with which required information can be written and read to and from the area sensor without using a cumbrous device such as a personal computer.

Means for Solving the Problems

To achieve the above-described object, as set forth in claim **1**, a first characteristic configuration of an area sensor according to the present invention is that the area sensor includes: a sensor unit that emits measurement light with which a monitoring area is scanned, and detects reflected light of the measurement light; and a system controller that controls the sensor unit to output sensor information to an external device, the sensor information including object information in the monitoring area obtained based on an output signal from the sensor unit. The system controller includes a memory interface to which a portable external storage device is connectable, a sensor controller that controls the sensor unit, and a memory controller that accesses the external storage device and a start processing unit which operates the memory controller in priority to the system controller, when the external storage device is connected to the memory interface.

When the portable external storage device is set to the memory interface, the external storage device and the area sensor can exchange data, with the memory controller of the system controller operating with priority over the sensor controller due to control performed by the start processing unit. The external storage device is portable and thus can be extremely easily carried to various installed environments of the area sensor. Furthermore, the external storage device can be detachably attached. Thus, usability can be largely improved.

As described in claim **2**, a second characteristic configuration of the area sensor is that, in addition to the above-described first characteristic configuration, the memory controller is configured to execute authentication processing to compare an identification code stored in the external storage device to an identification code uniquely set to the area sensor.

The memory controller compares the identification code stored in the external storage device and the identification code uniquely set to the area sensor, to evaluate whether the external storage device is appropriate to the area sensor. Higher security can be achieved with required processing executed based on a result of the evaluation.

As described in claim **3**, a third characteristic configuration of the area sensor is that, in addition to the above-described second characteristic configuration, the memory controller is configured to execute read processing and/or write processing based on a command stored in the external storage device, when the identification codes match in the authentication processing.

When the identification code stored in the external storage device and the identification code uniquely set to the area sensor match as a result of the comparison, the memory controller determines that an appropriate external storage device has been connected. Then, the read processing or the write processing is executed based on the command stored in the external storage device. Thus, with a required command stored in the external storage device in advance, the memory controller automatically executes processing required for the area sensor. As a result, the external storage device can be flexibly used.

As described in claim **4**, a fourth characteristic configuration of the area sensor is that, in addition to the above-described second or third characteristic configuration, the memory controller is configured to execute read processing and/or write processing based on a command which is associated with the identification code and stored in the external storage device when the identification codes match in the authentication processing.

The command stored in the external storage device is associated with the identification code. Thus, processing unique to each identification code can be executed. In other words, processing unique to each of the area sensors to which the same external storage device is connected can be executed. As a result, the external storage device can be more flexibly used.

As described in claim **5**, a fifth characteristic configuration of the area sensor is that, in addition to the above-described third or fourth characteristic configuration, the system controller includes a storage unit that is segmented into a program storage area storing therein an operation program of the area sensor and a data storage area storing therein information on the monitoring area, and a CPU that executes the program stored in the program storage area of the storage unit, the memory controller is implemented with the CPU, and the CPU executes an access program, for accessing the external storage device, in the program stored in the program storage area, and the memory controller executes read processing or write processing based on the command stored in the external storage device, the read processing including reading an update program from the external storage device and writing the update program to the program storage area or including reading control information from the external storage device and writing the control information to the data storage area, the write processing including reading, by the sensor controller, sensor information stored in the data storage area or reading control information stored in the data storage area and writing the sensor information or the control information to the external storage device.

The memory controller includes the access program, for accessing the external storage device, stored in the program storage area of the storage unit and the CPU that reads and executes the access program. When the command stored in the external storage device is the read command, the memory controller reads an update program from the external storage device and writes the update program to the program storage area, and reads control information and writes the control information to the data storage area. When the command stored in the external storage device is the write command, the memory controller reads the sensor information stored in the data storage area or the control information stored in the data storage area, and writes the sensor information or the control information to the external storage device. Thus, when the read processing is executed, the operation program of the area sensor is updated with the program stored in the external storage device, or the control information is set. When the write processing is executed, the sensor information or the control information stored in the storage unit of the area sensor is loaded into the external storage device.

As described in claim **6**, a sixth characteristic configuration of the area sensor is that, in addition to the above-described fifth characteristic configuration, the control infor-

mation includes any one of area information that defines the monitoring area, number of areas information that defines number of the monitoring areas, interlock information that holds sensor information output to the external device, restart information for automatically or manually resetting the sensor information output to the external device, and master-slave information that defines the area sensor to operate as master or slave upon being connected to a network.

When the read processing is executed, in the area sensor, the monitoring area is set if the control information is the area information, the number of monitoring areas is set if the control information is the number of areas information, the state where the object is detected in the monitoring area is maintained if the control information is the interlock information, and the state where the object is detected in the monitoring area is automatically or manually reset if the control information is the restart information. Specifically, when no object is detected in the monitoring area, the state where the object is detected is automatically reset or manually reset by an input operation using a switch or the like. If the control information is the master-slave information, each of the plurality of area sensors connected is set to operate as a master area sensor or a slave area sensor.

When the write processing is executed, the control information set to the area sensor is stored in the external storage device. For example, the control information stored in the external storage device is reused for other area sensors thereafter.

As described in claim **7**, a seventh characteristic configuration of the area sensor is that, in addition to the above-described fifth or sixth characteristic configuration, the sensor information includes the output signal from the sensor unit and the object information in the monitoring area obtained based on the output signal.

The sensor information, stored in the data storage area and written to the external storage device, includes the output signal from the sensor unit and the object information in the monitoring area obtained based on the output signal. The sensor information is loaded as the history information.

As described in claim **8**, a first characteristic configuration of an external storage device according to the present invention is that the external storage device is connected to the area sensor according to any one of the above-described first to seventh characteristic configurations and stores therein at least one identification code for identifying an area sensor to be a target of the write processing or the read processing, a write command or a read command associated with the at least one identification code, and data identifying information for identifying data to be a target of the write command or the read command.

As described in claim **9**, a second characteristic configuration of the external storage device is that, in addition to the above-described first characteristic configuration, the external storage device includes any one of a portable SD memory, a USB memory, and a hard disk.

Effects of Invention

As described above, the present invention can provide an area sensor and an external storage device with which required information can be written and read to and from the area sensor without using a cumbrous device such as a personal computer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a perspective view of an area sensor according to the present invention and FIG. **1**B is a side view of the same.

FIG. **2** is a diagram illustrating an internal structure of the area sensor.

FIG. **3** is a diagram illustrating an example of a monitoring area.

FIG. **4** is a diagram illustrating functional blocks of a sensor unit and a system controller of the area sensor.

FIG. **5** is a diagram illustrating a data map stored in an external storage device.

FIG. **6** is a flowchart illustrating processes for exchanging data between the external storage device and the area sensor.

FIG. **7** is a diagram illustrating functional blocks of a sensor unit and a system controller according to another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An area sensor and an external storage device according to the present invention are described below.

FIGS. **1**A and **1**B are outer views of an area sensor **2** (hereinafter, also referred to as a laser sensor **2**), and FIG. **2** illustrates an internal structure of the laser sensor **2**. The present embodiment is described under a condition that the area sensor **2** is installed in a moving member such as an automatic guided vehicle (hereinafter, referred to as "AGV") to be used as a safety sensor that detects an obstacle on a traveling route. The AGV conveys materials and the like in a manufacturing site and the like.

As illustrated in FIGS. **1**A and **1**B, the laser sensor **2** includes a lower casing **2**A having an approximately rectangular parallelepiped shape and an upper casing **2**C including an optical window **2**B having an inverted truncated conical shape. The lower casing **2**A has a back surface provided with a communication connector CN**1** for a local area network (LAN). An input/output cable S including a plurality of signal lines extends from the back surface.

The lower casing **2**A has a front surface provided with a two-digit segment display unit **2**E indicating an operation status of the area sensor **2** and a monitor display unit **2**F including arrays of three light emitting diodes (LEDs) on left and right sides of the segment display unit **2**E.

A secure digital (SD) card connector **2**G and a universal serial bus (USB) connector **2**H, each covered with an openable cover, are provided below the monitor display unit.

As illustrated in FIG. **2**, the area sensor **2** includes a light emitting unit **3**, a light receiving unit **4**, a polarization mirror **5**, a scanning mechanism **6**, a light receiving lens **7**, a control board **8**, and the like.

The scanning mechanism **6** includes a motor **60** provided on an upper inner wall of the upper casing **2**C and an encoder **61** that detects a rotation status of the motor **60**. The polarization mirror **5** is rotatably attached to a rotation shaft while being inclined by an angle of 45° relative to the rotation shaft of the motor **60**. The encoder **61** functions as a scanning angle detection unit for measurement light.

The light emitting unit **3** and the light receiving unit **4** are coaxially arranged with respect to the rotation shaft of the motor **60**. The light emitting unit **3** includes a laser diode **3***a* for light with a wavelength in an infrared range and a light projecting lens **3***b*. The light receiving unit **4** includes a photodiode **4***a* and an amplifier circuit **4***b*, and is provided on the control board **8** in a bottom portion of the lower casing **2**A.

The control board **8** is provided with a signal processing unit and a system controller. The signal processing unit controls driving of the motor **60** based on a signal from the encoder **61**, controls the laser diode **3***a* to emit light at a

predetermined timing, and processes a signal corresponding to light received by the light receiving unit **4**. The system controller controls the area sensor **2**.

The light receiving lens **7** has a circumference portion fixed to a flange portion **72** of a lens holder **70** having four leg portions **71**. A tubular light projecting lens holder **3**B is inserted to a cylindrical notch portion **7***a* formed at a portion corresponding to an optical-axis center of the light receiving lens **7**. The light projecting lens **3***b* is provided in the light projecting lens holder **3**B and is held by a lens holder **3**C from above to be fixed.

The laser diode **3***a* is mounted on a rectangular substrate **3***d* on a lower end portion of the light projecting lens holder **3**B. The substrate **3***d* has an end portion fixed to the flange portion **72** of the lens holder **70** with a bolt. The control board **8** is fixed by the four leg portions **71** of the lens holder **70**.

Pulsed measurement light output, after beam forming by the light projecting lens **3***b*, from the light emitting unit **3** is incident on the polarization mirror **5**. The measurement light is polarized and reflected by the polarization mirror **5**, driven to be rotated by the motor **60**, to pass through the optical window **2**B. A monitoring area R is scanned with this measurement light.

The reflected light of the measurement light passes through the optical window **2**B to be incident on the polarization mirror **5** and is then focused onto the light receiving unit **4** by the light receiving lens **7**. The reflected light is converted into an electrical signal by the light receiving unit **4**, to be input to the signal processing unit.

The light emitting unit **3**, the, light receiving unit **4**, the polarization mirror **5**, the scanning mechanism **6**, the light receiving lens **7**, and the signal processing unit provided to the control board **8** described above forms a sensor unit **10**. The sensor unit **10** scans the monitoring area R with the measurement light, and detects the reflected light of the measurement light.

FIG. **4** is a diagram illustrating functional blocks of the sensor unit **10** and the system controller **20**. The signal processing unit **9** incorporated in the sensor unit **10** includes an arithmetic circuit such as a digital signal processor, and includes functional blocks including a distance calculation unit **9**A, a correction processing unit **9**B, a correction data storage unit **9**C, and a pulse signal generation unit **9**D

The pulse signal generation unit **9**D performs control in such a manner that the pulsed measurement light is output from the light emitting unit **3** at a predetermined interval to be synchronized with pulses from the encoder **61** serving as the scanning angle detection unit. The light receiving unit **4** receives reflected light that is the measurement light reflected by a surface of any object.

The distance calculation unit **9**A calculates a distance between the area sensor **2** and a position where the measurement light has been reflected, based on delayed time between a measurement light output timing and a reflected light detection timing.

The correction processing unit **9**B corrects the distance, calculated by the distance calculation unit **9**A, based on correction data stored in the correction data storage unit **9**C, and outputs the resultant distance data to the system controller **20**.

The correction data is for correcting an error including: a production error of individual area sensor **2**; and an error due to the response characteristics of the photodiode **4***a* used in the light receiving unit **4**. The correction data is a value calculated based on measurement light emitted onto a reference reflector provided in the area sensor **2**, and a timing at which reflected light of the measurement light is detected.

The system controller **20** includes a microcomputer incorporating a flash read only memory (ROM) and a peripheral circuit including a communication interface **23** (hereinafter, referred to as a "communication I/F") and a memory interface **30** (hereinafter, referred to as a "memory I/F"). The flash ROM serves as a storage unit **21** according to the present invention. Functional blocks **22**, including the sensor controller **22**B and the memory controller **22**C according to the present invention, are implemented with a central processing unit (CPU) executing a program stored in the flash ROM.

The functional blocks **22** further include a communication I/F controller **22**A that controls the communication I/F **23**, in addition to the sensor controller **22**B that controls the sensor unit **10** and the memory controller **22**C that controls the memory interface **30**.

The communication I/F **23** includes a signal input/output port, a serial signal port, and a LAN port. A plurality of input signal lines and output signal lines are connected to the signal input/output port. A communication line supporting RS485 is connected to the serial signal port. The LAN is for establishing network connection using a protocol such as Transmission Control Protocol/Internet Protocol (TCP/IP).

The input/output cable S in FIG. **1**B is connected to the signal input/output port. A twisted pair communication line, supporting RS485, is provided as a part of the input/output cable S connected to the serial signal port. A LAN cable has a connector connected to the communication connector CN**1** in FIG. **1**B.

The memory interface **30** is for connecting a portable storage medium, and includes the SD card connector **2**G and the USB connector **2**H in FIG. **1**A. In this example, a portable storage medium to be connected to the SD card connector **2**G is an SD memory, and a portable storage medium connected to the USB connector **2**H is a USB memory, a hard disk, or the like.

The storage unit **21** is segmented into a program storage area **21**F and a data storage area (**21**A to **21**E). The program storage area stores therein a sensor control program for causing the CPU to function as the sensor controller **22**B, and a memory control program for causing the CPU to function as the memory controller **22**C.

The data storage area is segmented into data storage areas including: a parameter storage area **21**A storing therein a parameter for setting an operation mode of the area sensor **2**; a monitoring area storage area **21**B where a monitoring area of the area sensor **2** is set; a distance data storage area **21**C storing therein distance data received from the sensor unit **10**, that is, distance data for each predetermined scanning angle; a history data storage area **21**D storing therein a history of sensor information output to an external device based on the distance data received from the sensor unit **10**; and an identification code storage area **21**E storing therein an identification code such as an ID and a serial number for uniquely identifying the area sensor.

The parameter storage area **21**A stores therein information including: a number of areas information defining the number of monitoring areas; interlock information for holding the sensor information that has been output to the external device; restart information for automatically or manually resetting the sensor information that has been output to the external device; and master-slave information defining whether the area sensor operates as master or slave upon being connected to a network.

The monitoring area storage area **21**B stores therein data defining an area monitored with the area sensor **2**. The monitoring area is set in accordance with the number of areas information described above. For example, when the number of areas is two, two monitoring areas are set.

FIG. **3** illustrates an example where the area sensor **2** installed in the AGV **1** has two monitoring areas R**1** and R**2** set, along the traveling direction of the AGV **1**, for detecting whether there is an entering object such as a person or an obstacle. Specifically, the first monitoring area R**1** is set to be close to the AGV **1** and the second monitoring area R**2** is set to be adjacent to the first monitoring area R**1** and to be farther from the AGV **1** than the first monitoring area R**1** is. In FIG. **3**, an area defined with a one-dot chain line is a detectable area of the area sensor **2**, and the monitoring areas are set in this area.

For example, when the area sensor **2** detects an entering object, such as a person or an obstacle, in the second monitoring area R**2**, a warning signal is output to the controller of the AGV **1**. Upon receiving the signal, the controller of the AGV **1** outputs a warning signal for emitting sound or light to prevent collision or performs control to decelerate and stop the AGV **1**.

For example, when the area sensor **2** detects the entering object, such as a person or an obstacle, in the first monitoring area R**1**, an emergency stop signal is output to the controller of the AGV **1**. Upon receiving the signal, the controller of the AGV **1** performs emergency stop control so that the AGV **1** immediately stops to be prevented from colliding with the entering object.

When the area sensor **2** starts, the sensor controller **22**B controls driving of the motor control circuit **62**, based on the encoder pulse received from the scanning angle detection unit **61**, to achieve the constant rotation speed of the motor **60**. Then, when the motor **60** starts up, the sensor controller **22**B outputs an instruction to start distance measurement processing to the signal processing unit **9**.

Upon receiving the distance data for each predetermined scanning angle from the signal processing unit **9**, the sensor controller **22**B determines whether each distance data indicates a position in a monitoring area set in the monitoring area storage area **21**B. When the distance data indicates a position in the monitoring area, the sensor controller **22**B outputs a required signal, such as the warning signal or the emergency stop signal, to the external device through the communication I/F **23**, and stores the history of the signal output in the history data storage area **21**E.

When the interlock information is set in the parameter storage area **21**A, the state of outputting the emergency stop signal or the like is maintained even if no distance data indicating a position in the monitoring area is obtained by distance measurement thereafter.

In the parameter storage area **21**A, the automatic restart information may be set with the interlock information not set. Under this condition, when no distance data indicating a position in the monitoring area is obtained by the distance measurement thereafter, the state of outputting the emergency stop signal or the like is reset. Furthermore, the manual restart information may be set. Under this condition, when no distance data indicating a position in the monitoring area is obtained by the distance measurement thereafter, the state of outputting the emergency stop signal or the like is reset at a timing when a reset signal is manually input through the communication I/F **23**.

A plurality of the area sensors **2**, connected to each other through a communication line supporting RS485, may be installed in the AGV **1**. In this configuration, the area sensor **2** set to operate as the master in the parameter storage area **21**A is connected to the controller of the AGV **1**. The area sensor **2** set to operate as the master acquires the warning signal or the emergency stop signal, output from the other area sensor **2** set to operate as the slave, through the communication line, and outputs the acquired signal to the controller of the AGV **1**.

The data such as the parameter stored in the parameter storage area **21**A and the monitoring area stored in the monitoring area storage area **21**B, is configured to be set and input with a personal computer connected to the communication connector CN**1**, under a normal condition.

A program stored in the program storage area **21**F is updated with the program rewritten with the personal computer.

However, a configuration where the personal computer is connected to each of the area sensors **2** to set and input data requires extremely cumbersome procedures. Thus, the area sensor **2** according to the present invention is configured in such a manner that data can be set and read or a program can be updated via a portable external storage device.

When an SD memory, which is one example of the external storage device, is connected to the memory I/F **30**, the memory I/F **30** outputs an interrupt signal to the CPU.

As a result, a state is established where the SD memory and the area sensor **2** can exchange data with the memory controller **22**C operating with priority over the sensor controller **22**B operating under the normal condition.

The memory controller **22**C executes authentication processing of comparing an identification code stored in the SD memory and a unique identification code stored in the identification code storage area **21**E of the area sensor **2**. When the identification codes match, read processing and/or write processing is executed based on a command stored in the SD memory.

The SD memory stores therein in advance, data set in the parameter storage area **21**A of the area sensor **2**, monitoring area data set in the monitoring area storage area **21**B, an update program for updating a program in the program storage area **21**F, and the like. A data storage area is set in the SD memory. The data storage area stores therein distance data stored in the distance data storage area **21**C and history data stored in the history data storage area **21**D.

In the SD memory, a command code and a condition code are set in association with the identification code of each of the area sensors **2**. The command code designates an operation to be performed including; writing data or an update program to the storage unit **21** of the area sensor **2**; and reading data from the storage unit **21** of the area sensor **2**. The condition code designates the type and location of write or read target data.

When the identification code set in the identification code storage area **21**E is determined to be stored in the SD memory in the authentication process, the memory controller **22**C determines that an appropriate SD memory is connected. Then, the memory controller **22**C reads the command code and the condition code associated with the identification code, and automatically executes corresponding processing.

Specifically, when the SD memory stores therein the program read command, the memory controller **22**C reads an update program from the SD memory, and writes the update program to the program storage area in the storage unit **21**. When the SD memory stores therein the data read command, the memory controller **22**C reads control information from the SD memory, and writes the control information to the data storage area.

When the SD memory stores therein the data write command, the memory controller **22**C executes write processing of reading sensor information or control information stored in the storage unit **21**, and writing the information to the SD memory.

Thus, with an SD memory attached to the individual area sensor **2**, a monitoring area and a parameter required for the area sensor **2** can be set, and update processing can be executed for the control program.

From the area sensor **2** in which the monitoring area has been set, data for setting the monitoring area to the SD memory can be loaded, so that the data can be set to the other area sensor **2**.

The memory controller **22**C is not limited to a configuration of reading the command code and the condition code associated with the identification code and automatically executing the corresponding processing when it is determined that an appropriate SD memory is connected. Alternatively, the memory controller **22**C may be configured to execute corresponding processing in accordance with an operation status of an external operation switch connected to a start processing unit **31**. For example, in the example illustrated in FIG. **4**, a configuration may be employed in which the write processing starts when a switch for inputting a write signal to the start processing unit **31** is operated, and the read processing starts when a switch for inputting a read signal is operated.

FIG. **5** illustrates an exemplary data map of the command code, the condition code, the identification code, and the like stored in the SD memory.

For example, the map indicates that area sensors with identification codes **1** to **5** have the same monitoring area and the same parameter set and are updated with the same update program, that the monitoring area and the history data are loaded from an area sensor with an identification code **6**, and that area sensors with identification codes **7** to **9** are updated with same update program.

Thus, the SD memory may store in advance required data including an identification code, a write or read command, a condition code indicating target data, and head storage addresses of the external storage device and the area sensor, so that the memory controller **22**C can execute required processing on the area sensor **2**. Thus, the SD memory can be flexibly used.

FIG. **6** illustrates an example of a procedure of data read processing and data write processing executed between the external storage device and the area sensor.

When the external storage device is connected to the memory I/F **30** of the area sensor **2**, a code indicating that the external storage device is connected is displayed on the segment display unit **2**E (see FIG. **1**A) of the lower casing **2**A (SA**1**). Then, the memory controller **22**C determines which one of the write signal (command) and a read signal (command) has been set and input from the start processing unit **31** (SA**2**).

When the write signal has been set and input, required data is read from the data storage area to generate output data (SA**3**), and coding processing for error detection is executed (SA**4**). Then, encoding processing is executed (SA**5**), and resultant data is output to the external storage device (SA**6**). The coding processing employed may be appropriate known technique including adding a Cyclic Redundancy Check (CRC) code, setting a parity bit, and the like.

When the read signal is determined to have been set and input in step SA**2**, the memory controller **22**C loads data from the external storage device into a buffer (SA**7**), and then the data is decoded (SA**8**).

Then, error check is performed on the data (SA**9**). When the data is appropriate data, an identification code is extracted in the subsequent step (SA**10**). The identification code thus extracted is compared with the identification code stored in the identification code storage area (SA**11**).

When the codes match and thus the data is successfully authenticated (SA**11**), the data is written to the storage unit **21**. Then, the data thus written is compared with the original data (SA**13**). When the data match the original data, a data write completed code is displayed on the segment display unit **2**E (see FIG. **1**A) (SA**14**).

When an error is found in the data in step SA**9**, the identification code is not extracted in step SA**10**, or the authentication fails in step SA**11**, an error code is displayed on the segment display unit **2**E (see FIG. **1**A) (SA**15**). Until the external storage device is determined to be connected in step SA**1**, the sensor controller **22**B controls the sensor unit **10**.

In the example described above, when the write signal is set and input, corresponding data is uniquely loaded into the external storage device, without authenticating the identification code. Alternatively, a configuration may be employed in which the authentication is performed on the identification code and then data to be loaded into the external storage device is checked, before being loaded into the external storage device.

Specifically, the system controller **20** includes the storage unit **21** and a CPU. The storage unit **21** is segmented into the program storage area **21**F that stores therein an operation program for the area sensor **2** and the data storage areas **21**A to **21**D that store therein information related to the monitoring area. The CPU executes the program stored in the program storage area **21**F of the storage unit **21**. The memory controller **22**C includes an access program for accessing the external storage device, which is one of the programs stored in the program storage area **21**F, and a CPU that executes the access program.

Then, based on a command stored in the external storage device, the memory controller **22**C executes read processing of reading an update program from the external storage device and writing the update program to the program storage area **21**F or reading control information from the external storage device and writing the control information to the data storage areas **21**A and **21**B. Alternatively, the sensor controller **22**B executes write processing of reading the sensor information stored in the data storage areas **21**C and **21**D or reading the control information stored in the data storage areas **21**A and **21**B, and writing the information thus read to the external storage device.

The external storage device according to the present invention is connected to the area sensor **2**, and stores therein one or a plurality of identification codes, a write command or a read command corresponding to each identification code, and data identification information for identifying data that is a target of the write command or the read command. The identification code is for identifying the area sensor **2** that is a target of the write processing or the read processing.

In the example described above, a portable SD memory is used as the external storage device. Alternatively, any appropriate portable storage device such as a portable semiconductor memory including a USB memory and a hard disk and a storage such as a magnetic disk may be employed.

In the exemplary embodiment described above, the memory interface **30** and the start processing unit **31** are

accommodated in the lower casing **2**A of the laser sensor **2**. Alternatively, the memory interface **30** and/or the start processing unit **31** may be formed separately from the laser sensor **2**.

As illustrated in FIG. **7**, the memory interface **30** and the start processing unit **31** may be formed separately from the laser sensor **2**, and may be formed as an external module M that can be connected to the laser sensor **2** through a connector **30**CN to which a signal line for interface is connected.

The embodiment described above is merely an example of an area sensor and an external storage device according to the present invention. A specific structure of the laser sensor, and a specific circuit configuration of the signal processing unit and the system controller can be modified as appropriate as long as the advantageous effect of the present invention can be obtained. Thus, the technical scope of the present invention is not limited to the examples described above.

The invention claimed is:

1. An area sensor comprising:

a sensor in which a distance measurement device is incorporated, the sensor with the distance measurement device measuring a distance by emitting a measurement light with which a monitoring area is scanned and detecting a reflected light of the measurement light;

a memory interface for connecting a removable external storage device;

a communication interface which outputs a signal to an external device different from the removable external storage device; and

a processor programmed to:

control the sensor to output sensor information to the external device through the communication interface, the sensor information including object information in the monitoring area obtained based on an output signal from the sensor; and

in response to determining that the removable external storage device is connected to the memory interface,

execute authentication processing by comparing an identification code stored in the removable external storage device and an identification code uniquely set to the area sensor; and

access the removable external storage device, such that data exchange via the memory interface of the area sensor takes priority over data exchange via the communication interface of the area sensor.

2. The area sensor according to claim **1**, wherein:

in response to determining that the removable external storage device is connected to the memory interface, the memory interface automatically outputs an interrupt signal to the processor of the area sensor; and

in response to the interrupt signal, an operation over the memory interface is processed in priority to an operation over the communication interface in normal condition.

3. The area sensor according to claim **2**, wherein the processor is programmed to:

execute a read processing and/or a write processing based on a command which is (i) associated with the identification code uniquely set to the area sensor and (ii) stored in the removable external storage device, when the identification code uniquely set to the area sensor matches the identification code stored in the removable external storage device in the authentication processing.

4. The area sensor according to claim **1**, wherein the processor is programmed to:

execute a read processing and/or a write processing based on a command which is (i) associated with the identification code uniquely set to the area sensor and (ii) stored in the removable external storage device, when the identification code uniquely set to the area sensor matches the identification code stored in the removable external storage device in the authentication processing.

5. The removable external storage device connected to the area sensor according to claim **1**, the removable external storage device storing therein:

at least one identification code for identifying an area sensor to be a target of the write processing or the read processing,

a write command or a read command associated with the at least one identification code, and

data identifying information for identifying data to be a target of the write command or the read command.

6. The removable external storage device according to claim **5**, wherein the removable external storage device includes any one of a removable SD memory, a USB memory, and a hard disk.

7. The area sensor according to claim **1**, wherein:

the processor of the area sensor updates the monitoring area that is to be scanned with the measurement light based on the data exchange via the memory interface; and

the monitoring area and parameters for scanning the monitoring area are reset according to a command stored in the removable external storage device.

8. The area sensor according to claim **1**, wherein

the sensor information is output to the external device at a timing determined based on a command stored in the removable external storage device.

9. The area sensor according to claim **1**, wherein

the external device is at least one of a robot and an automatic guided vehicle.

10. The area sensor according to claim **1**, wherein

a program executed by the processor of the area sensor is updated by connecting the removable external storage device to the memory interface without connecting a personal computer.

11. The area sensor according to claim **1**, wherein

the removable external storage device stores a command for the area sensor and a condition associated with the command, the condition designating a type and a location of a target data on which an operation designated by the command is to be performed.

12. The area sensor according to claim **1**, wherein:

the removable external storage device stores a command for the area sensor; and

the command resets the monitoring area that is scanned with the measurement light.

13. An area sensor comprising:

a sensor that emits measurement light with which a monitoring area is scanned, and detects reflected light of the measurement light;

a memory interface for connecting a removable external storage device; and

a processor programmed to:

control the sensor to output sensor information to an external device, the sensor information including object information in the monitoring area obtained based on an output signal from the sensor;

access the external storage device to execute authentication processing to compare an identification code stored in the external storage device to an identifi-

cation code uniquely set to the area sensor, and to execute read processing and/or write processing based on a command which is (i) associated with the identification code uniquely set to the area sensor and (ii) stored in the external storage device, when the identification code uniquely set to the area sensor matches the identification code stored in the external storage device in the authentication processing;

execute a program stored in a program storage area of a storage unit inside the area sensor, the storage unit being segmented into the program storage area storing therein an operation program of the area sensor and a data storage area storing therein information on the monitoring area;

execute an access program, for accessing the external storage device, in the program stored in the program storage area; and

execute the read processing and/or the write processing based on the command stored in the external storage device,

the read processing including:

reading an update program from the external storage device and writing the update program to the program storage area, or

reading control information from the external storage device and writing the control information to the data storage area,

the write processing including:

reading sensor information stored in the data storage area of the storage unit and writing the sensor information to the external storage device, or

reading control information stored in the data storage area of the storage unit and writing the control information to the external storage device.

14. The area sensor according to claim **13**, wherein the control information includes any one of

area information that defines the monitoring area,

number of areas information that defines number of the monitoring areas,

interlock information that holds sensor information output to the external device,

restart information for automatically or manually resetting the sensor information output to the external device, and

master-slave information that defines the area sensor to operate as master or slave upon being connected to a network.

15. The area sensor according to claim **13**, wherein the sensor information includes the output signal from the sensor and the object information in the monitoring area obtained based on the output signal.

16. The area sensor according to claim **13**, wherein:

the control information includes any one of

area information that defines the monitoring area,

number of areas information that defines number of the monitoring areas,

interlock information that holds sensor information output to the external device,

restart information for automatically or manually resetting the sensor information output to the external device, and

master-slave information that defines the area sensor to operate as master or slave upon being connected to a network; and

the sensor information includes the output signal from the sensor and the object information in the monitoring area obtained based on the output signal.

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